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STUDY TO IMPROVE TWO-WAY RADIO COMMUNICATIONS

FINAL REPORT

by

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Prepared for

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1. INTRODUCTION

The objectives of this study have been to (1) investigate the present two-way radio communications at Sumter Electric Membership Corporation as to its effective coverage and areas of deficiencies, and (2) based on this investigation, recommend specific changes in the system configuration. The major emphasis has been directed to developing recommended changes which would provide the required performance at minimum cost and disruption to the existing system.

2. RESULTS OF STUDY

This radio communications study consisted of a series of tasks to first determine the operating characteristics of the existing system with emphasis on defining areas of deficiency. Following the problem definition task, the efforts were directed to developing alternative system configurations which would result in satisfactory system operation in a cost-effective manner. Several alternative configurations were developed and cost estimates assigned to each alternative. These cost estimates were based not only on initial equipment and installation costs but, where applicable, on long term recurring costs as well.

Information regarding the existing system was obtained from (1) manufacturer's data on various elements of the system and (2) discussions with cognizant Sumter EMC personnel. This latter source of information was very helpful, especially the numerous discussions held with Mr. Larry Dillard, Radio Dispatcher at Sumter EMC, who was able to supply significant information regarding pertinent characteristics of the communications system.

The major problem with the existing system is that of talk-back. Transmission between base and mobile was defined as being reliable 90 percent of the time in essentially all areas of the EMC district. However, transmission from mobile to base was said to be very poor for mobile units operating in the far western and southern areas of the district.

After sufficient information was obtained on characteristics of the communications system, range calculation were performed to compare actual operation with calculated, or expected, performance. These range calculations were performed on a Hewlett-Packard computer, Model 2100, using probability of intercept programs developed earlier by Georgia Tech personnel. Examples of these calculations are presented in Figures 1 through 5. Figure 1 shows the probability of intercept for base-to-mobile operation in the existing system; whereas Figure 2 shows the probability of intercept for mobile-to-base operation. In these figures, location of the base station at Americus is indicated by the single concentric circle pattern. Probability of intercept at each grid location is shown by squares with internal crosses. When the corners of a square touch the edges of a cross, the probability of intercept, i.e. chances of receiving a satisfactory signal, is 50 percent. For a square whose diagonal distance is twice that of the arm of the cross, the probability of interecept approaches 100 percent; such is the case for grids close to the base station. The difference between talk-out and talk-back is clearly indicated by comparing Figure 1 with Figure 2.

To alleviate the talk-back problem a number of alternatives were considered. Out of this list, three approaches were judged viable with all factors considered. Each of these alternatives involved erecting a tower in both the western and southern portions of the EMC district and of having a radio receiver (operating at 153.59 MHz) and associated antenna at each tower location. The purpose of the tower-located receivers would be to receive transmissions from the mobile units and relay the signal back to the base station. The primary difference in the three alternatives is the manner in which signals received at the remote locations are relayed backed to the base station at Americus.

The first of these alternatives consist of using leased telephone lines between the remotely located towers and the base station. The second alternative involves use of a microwave link for relaying the signal back to Americus. The third alternative is similar to the second except a UHF link is utilized rather than microwave. Use of leased telephone lines is attractive from the standpoint of low initial cost. However, because the lease rate on these lines is on the order of $150 per month for each of the two required set of lines, the long term cost becomes significant. The major difference between the second and third alternative is that of tower cost. A microwave link would utilize a parabolic dish antenna whereas the UHF link would use a Yagi antenna. Because of the narrow beam width of the parabolic dish and the wind loading factor, rigid towers are required as compared with standard guyed towers for Yagi antennas. The cost differential between the two tower types is almost six-to-one. Therefore, even through transmitters/receiver cost between UHF and microwave are similar, the increased microwave tower cost is certainly a negative factor.

A chart was prepared to provide a means for easy comparison between the three alternative configurations. This chart (Figure 6) shows not only initial cost but recurring costs as well. Use of the chart will be helpful in selecting the alternative which is best suited for both immediate and long-term needs. It is important to note that the dollar figures here presented are only for a single radio repeater site. Cost for two sites would be close to double; slightly less because a single receiver at the base location can be used for reception of signals from each of the two tower-located UHF or microwave transmitters. Receiver cost is about $1300 for UHF and $2700 for microwave.

Based on cost and performance factors it is our recommendation that the UHF link be implemented. This alternative is a cost-effective approach for alleviating the talk-back problem. We suggest the use of a low power (12-20 watts) UHF transmitter and associated receiver and antennas. This equipment is readily available from such manufacturers as Motorola and General Electric. Because of this recommendation, range calculations were performed to determine the expected performance of this low-power, (12 watt) UHF radio link. Figures 3 through 5 show the probability of intercept for three antenna heights with transmitter, receiver and antenna gains the same for each case. For a distance of 25 miles (40 kilometers) either a 100 or a 200 foot antenna height should provide a reliable link. However, since the cost difference between two such towers is minimal, it is recommended that the higher tower be used.

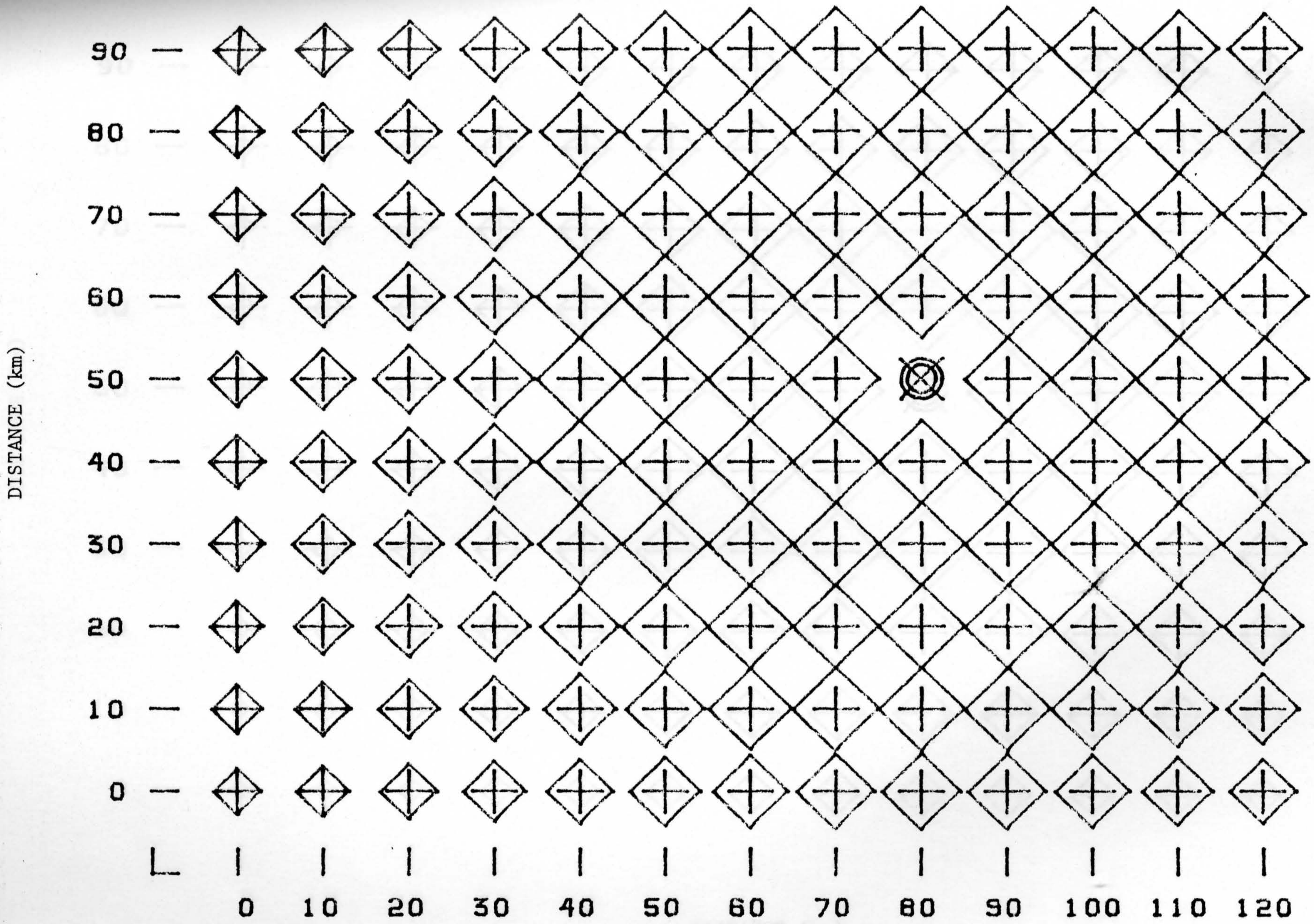

Figure 1. Probability of Intercept, Base-to-Mobile

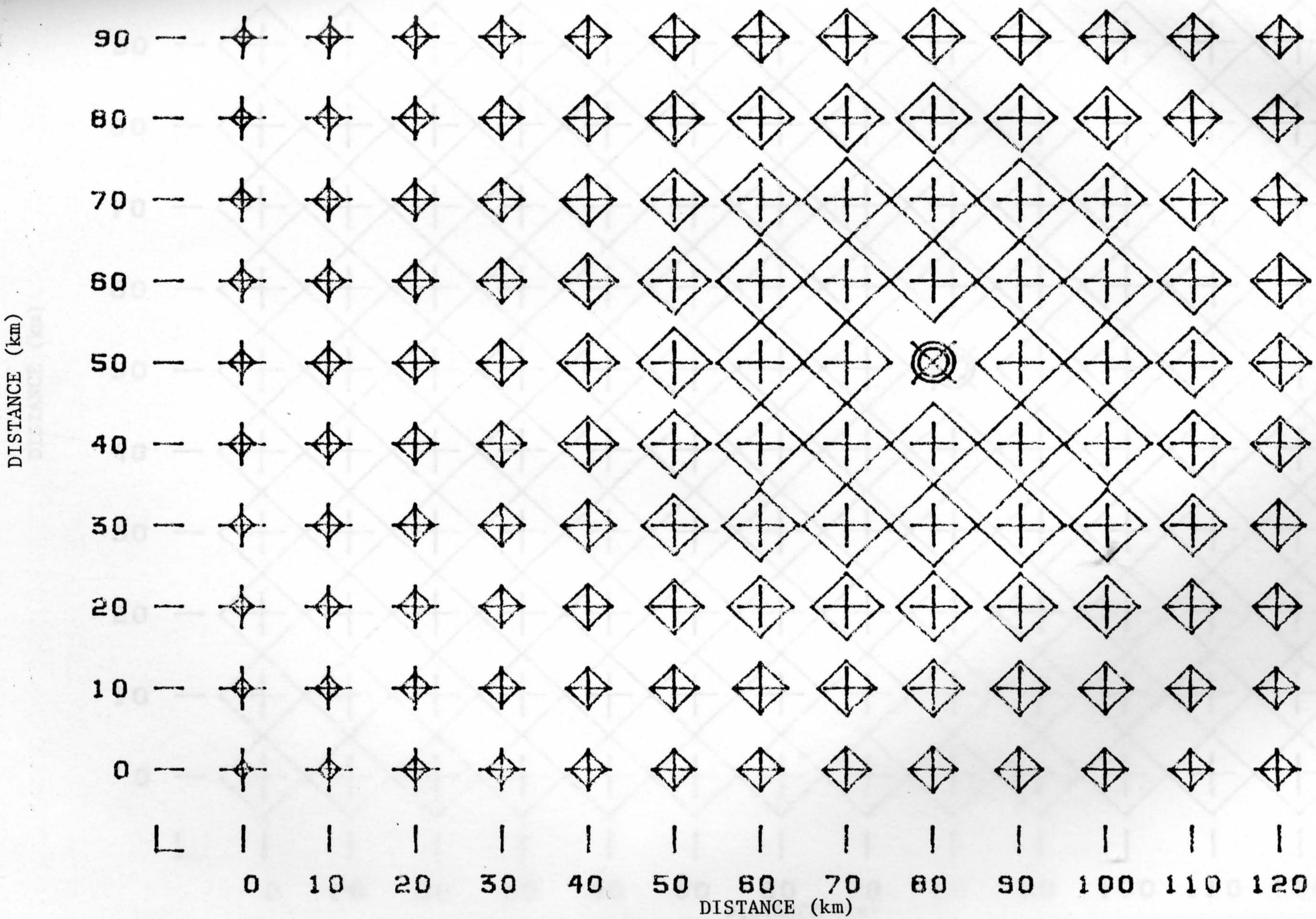

Figure 2. Probability of Intercept, Mobile-to-Base

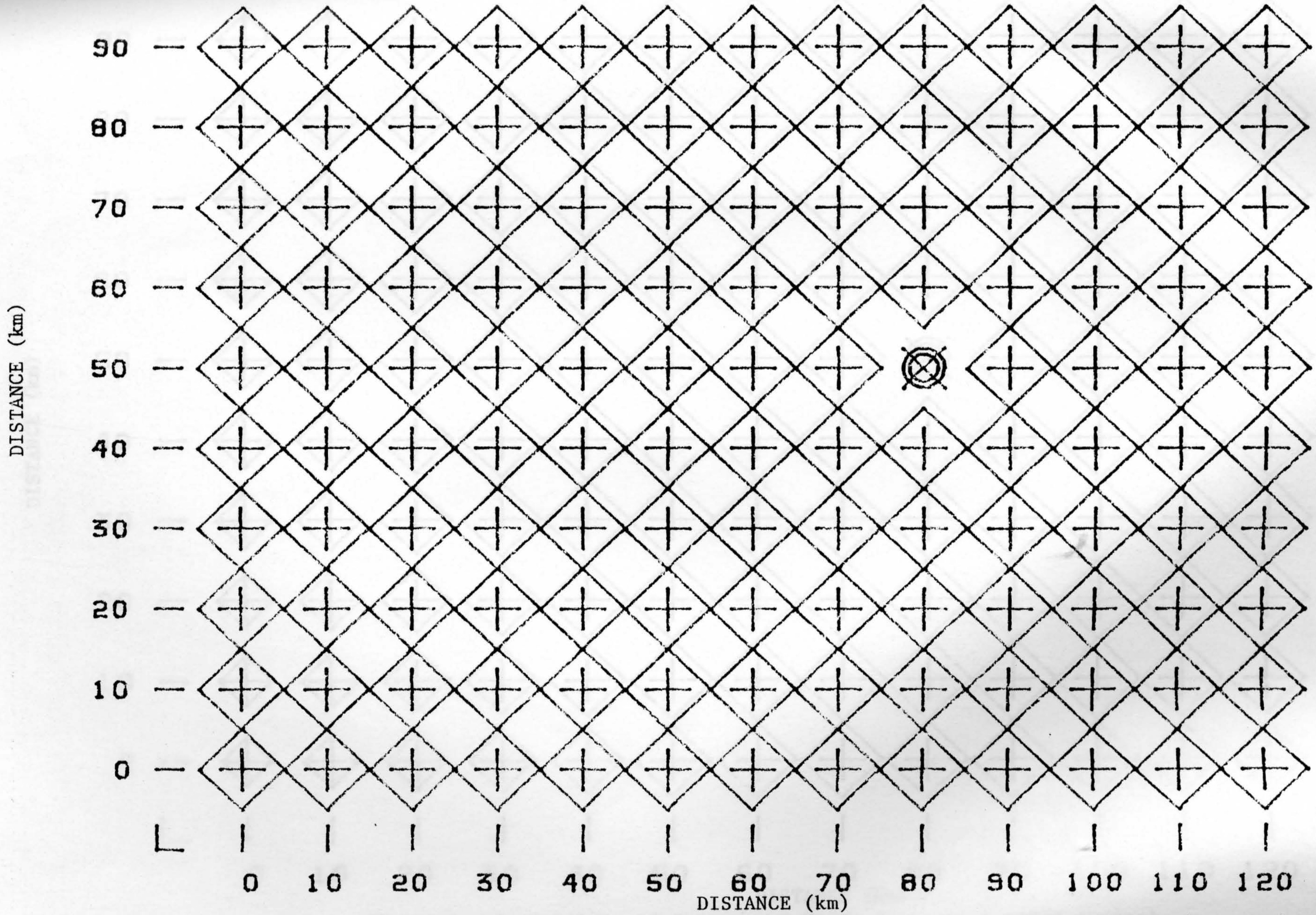

Figure 3. Probability of Intercept, Fixed Relay Link (200' towers)

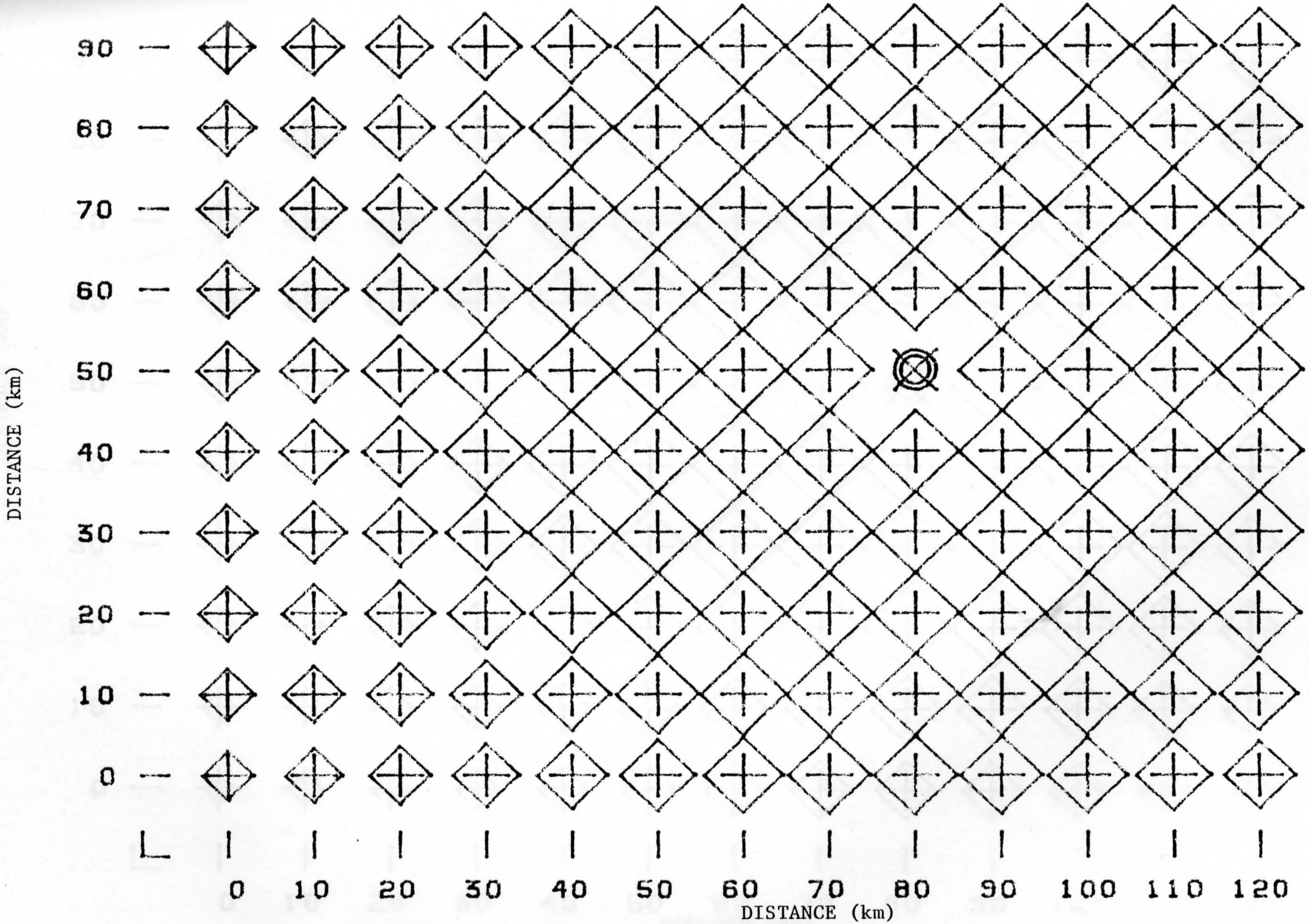

Figure 4. Probability of Intercept, Fixed Relay Link (100' towers)

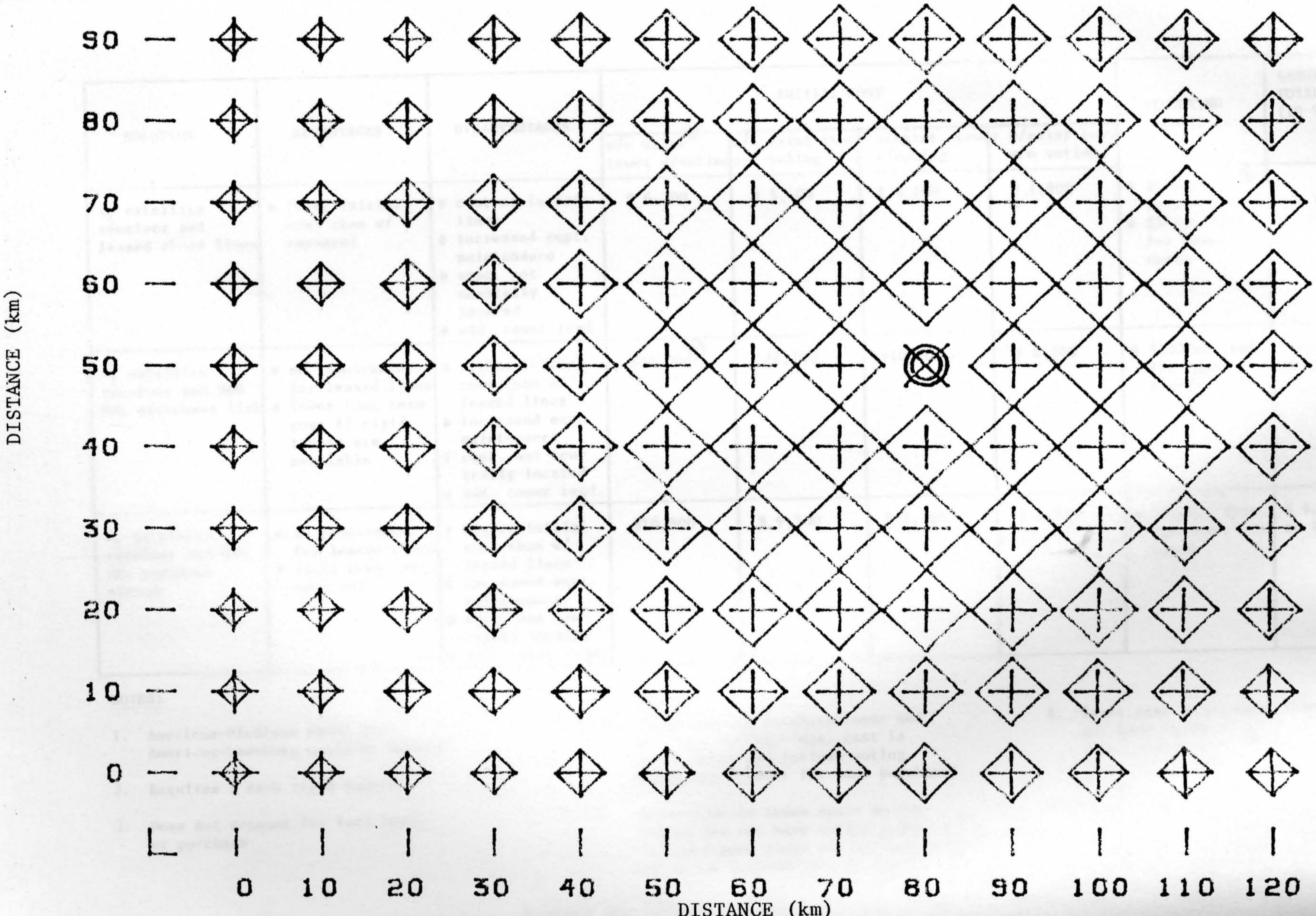

Figure 5. Probability of Intercept, Fixed Relay Link (30' towers)

SOLUTION	ADVANTAGES	DISADVANTAGES	INITIAL COST				RECURRING COSTS	RANGE OF TOTAL COST (10 Years)
			w/o exist tower w/voting [3]	w/o exist tower w/o voting	w/exist. tower w/voting	w/exist tower w/o voting		
f_1 satellite receiver and leased phone lines	• lower initial cost than w/ repeater	• cost of leased lines • increased eqpt. maintenance • eqpt. not centrally located • add. tower reqd	$ 6,700	$ 5,400	$ 3,200	$ 1,900	• $155/mo for [1] leased lines • $50/mo (est.) for tower space	$24,000 [4] to $27,800
f_1 satellite receiver and 900 MHz microwave link	• no requirement for leased lines • lower long term cost if rigid towers are available	• higher initial cost than w/ leased lines • increased eqpt. maintenance • eqpt. not centrally located • add. tower reqd.	$30,000 [7]	$28,700	$10,000	$ 8,700	• $100/mo (est) for tower space [2]	$20,700 [5] to $30,000
f_1 satellite receiver and 450 MHz repeater system	• no requirement for leased lines • rigid tower not required	• higher initial cost than w/ leased lines • increased eqpt. maintenance • eqpt. not centrally located • add. tower reqd.	$10,800	$ 9,500	$ 7,300	$ 6,000	• $50/mo. (est.) for tower space	$ 9,500 [6] to $13,300

NOTES:

1. Americus-Richland Phone line, Americus-Leesburg would be $126/mo
2. Requires 2 each rigid towers
3. Does not account for land lease or purchase
4. Least cost is purchase tower and not have voting - max. cost is lease tower and include voting (does not account for land purchase)
5. Least cost is lease space on two towers and not have voting - max. cost, purchase tower and include voting (does not include land purchase)
6. Least cost is purchase tower and not have voting - max. cost is lease tower and include voting (does not account for land purchase)
7. Accounts for purchase of only one tower - if purchase of two towers required, add $20,000

Figure 6. Costs Comparison of Alternative Systems